The Trigonometrical Survey of India, (Communicated by Major J. T. Walker.)

The following is the first of a Series of papers on matters of general interest connected with the Trigonometrical Survey of India, which it is proposed to extract from the manuscript volumes of the Survey, for publication in the Journal of the Asiatic Society. It is taken from the Introduction to the General Report of the North-East Longitudinal Series of triangles (G. T. Survey, Vol. XV.) drawn up under the Superintendence of Col. Sir Andrew Waugh, when Surveyor General of India, by J. B. N. Hennessey, Esq., 1st Assistant G. T. Survey.

The North-East Longitudinal Series derives its name from the circumstance of its following the course of the corresponding boundary of British India. It extends from the valley of the Dehra Dhoon to Purneah, connecting the northern extremities of the Calcutta Meridional Series and the celebrated Great Arc, measured by Cols. Lambton and Everest, on the meridian of Cape Comorin. Its object was to form the most direct connexion practicable between two base lines of verification, one measured in Dehra Dhoon, the other in Purneah. Thus it serves to close and verify the Meridional Series, 10 in number, which lie between the Great Arc and Calcutta Meridional Series and emanate from the longitudinal triangulation, connecting the Calcutta base with the Seronj base on the Great Arc in Central India.

This is the general system followed in the triangulation of India, which thus resembles in outline the form of a gridiron. At each angle of the gridiron, a base line is measured. The outer series form the frame-work on which the inner ones depend, and are especially valuable for the data they contribute towards the determination of the great problem of geodesy, the accurate measurement of the figure of the earth. By restricting the meridional, or inner series, to distances of 60 to 100 miles apart, all the necessary data for topographical operations are obtained, at a moiety of the cost that would be incurred in throwing a net work of triangles over the whole of India after the manner of European surveys, which require greater detail than is necessary in this country.

The North East Longitudinal Series was originally intended by Col. now Sir George Everest, C. B. to have been carried along the mountains on the British frontier. But this design was abandoned in consequence of the refusal of the Nepalese Government to allow the operations to enter their territories. Consequently, after crossing the hills of Kumaon and Gurhwal, the triangles were brought down into the Terai near Bareilly, from which point they lie almost continuously in the marshy and deadly tracts which fringe the Himalaya mountains. Here Lt. Reginald Walker, a very able and promising young officer, fell a victim to jungle fever. Being alone and without medical assistance, he strove to reach Darjeeling, but was found dead in his dhooly, on its arrival at that station. Of the native subordinates, a large percentage, one year no less than a fourth, died of jungle fever. Sickness was frequent and severe. On more than one occasion a whole party had to be literally carried into the nearest station for medical assistance. The completion of the major, and more difficult portion of the triangulation is due to the ability, courage and perseverance displayed by Mr. George Logan, who died three years afterwards, from disease first contracted in the Terai during these operations.

Owing to the proximity of the triangulation to the mountain ranges, the whole of the chief peaks were seen from the principal trigonometrical stations, and fixed by measurements with the first class instruments employed for the mutual observations between the stations themselves. These are called the "Principal Observations," for on them, the accuracy and value of the series, as a whole, depend. They are therefore taken with the largest and most powerful theodolites, which are expressly constructed for the Indian Survey, and furnished with micrometer microscopes, instead of verniers, for reading the graduations.

The employment of such instruments in secondary operations has the advantage of enabling the observer to attain as great accuracy by a few observations as by many with second class instruments; thus time is saved and reliable measurements of the higher mountains can be taken during the short intervals when their usually cloud-capped summits are unfurled to view.

The following extracts are chiefly relative to the computations for determining the heights and positions of the principal mountains.

A table of the resulting elements is given, together with a memorandum specifying the mountains which could be identified as having been previously observed by other surveyors. J. T. W.

Of the Secondary Mountain Triangulation.

57. The magnitude of the triangles for determining the positions of the hill peaks, and other unavoidable peculiarities attendant on the operations in general, have necessitated some few departures from ordinary precedents in the performance of the required calculations. These may be briefly noticed.

58. *Identification.*—The primary difficulty which the computer meets with is, in the identification of the numerous points whose positions have been determined. Observed by different persons, after long intervals or from different points of view under the disadvantages of altered aspects, the same hill will be found noted in the angle books under various characteristics. For instance, Mont Everest was called *v* by Colonel Waugh, *n* by Mr. Nicolson and *b* by Mr. Armstrong, while the peak XXXVIII. is named n^2 at one station of observation, n^3 at another and "I west peak" at a third, by the same observer. This plurality of characteristics, under the circumstances, is clearly unavoidable. It remains to state how the required identification was effected. The principal series was first carefully projected on a scale of 4 miles to the inch, and the several rays emanating from stations of observation were next exactly drawn. The intersection of these rays, assisted by the characteristics forthcoming in the angle books, more or less distinctly defined the points sought for. This was treated as an approximate identification, whereby the bases required from the principal series and expermiental triangles to be computed became known. The former were then obtained in the ordinary way, by means of the contained angle and logfeet of the including sides, for which computation the following well known formula was found useful,

$$\tan \tfrac{1}{2} (A - B) = \tan (45 - Q) \operatorname{Cot} \frac{C}{2}$$

$$\text{wherein } \tan Q = \frac{b}{a}$$

With the bases so found, the triangles were, as implied, first experimentally computed, an accordance of the numerous common sides demonstrating an identity of the several characteristic letters. In those cases where any want of demonstration existed, the point was rejected.

59. Such identification imposes no *experimental* calculation when the points observed are clearly isolated from each other. For instance XI. or Jannoo, XIII. and Mont Everest or XV. were readily identified by the angular projection. But as in the cases of XLIII., XLIV. and XLV. it is evident that nothing short of actual computation will separate the points in the group. The numerous experimental triangles by which non-identity was proved, as also the triangles for bases are not shown in this volume. The last mentioned triangles were about 450 in number, and the former also involved considerable labour.

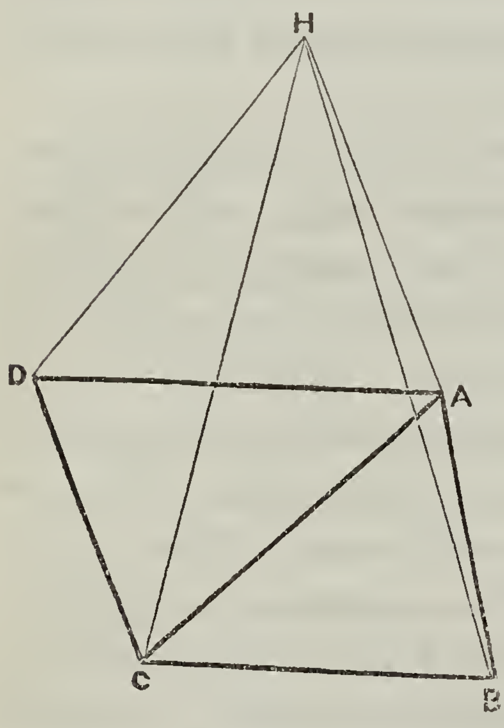
60. *Spheroidal excess.*—The two formulæ for spheroidal excess, viz., that involving two sides and the contained angle, and the other in terms of the base and the three angles, were respectively employed in the triangles for bases and in those to Himalayan points. In the latter case however, the spherical angle opposite the base c could, in the first instance, be only roughly found from the equation $\pi - (A + B) = C$, wherein A and B are spherical angles. Whence C was taken too small by the whole spheroidal excess. Now, as this latter frequently exceeds 100 seconds, it was sometimes required to find the excess approximately, next to correct the angle C, and then with this value of C, to recompute the excess finally. In other respects the Triangles were calculated as usually done.

61. *Synopsis of sides.*—The values of the sides in feet thus obtained were recorded in the form of a synopsis, and this paper was completed by finding the logarithm to the mean of these values, as well as the miles corresponding to the same.

62. *Latitude and Longitude.*—The computer was now prepared to deduce the required latitudes and longitudes, which was done in this wise. With the latitude and longitude of any station of observation A, the aximuth thereat of point n, and the mean distance from the synopsis of sides A to n, the latitude and longitude of n from A were found. Similarly values of latitude and longitude were obtained from the other stations of observation, and a mean of all these values was taken as *the* latitude and longitude of n.

63. The computation of heights was performed in the usual manner, until the estimation of terrestrial refraction was arrived at. The process adopted for this purpose may be briefly stated thus.

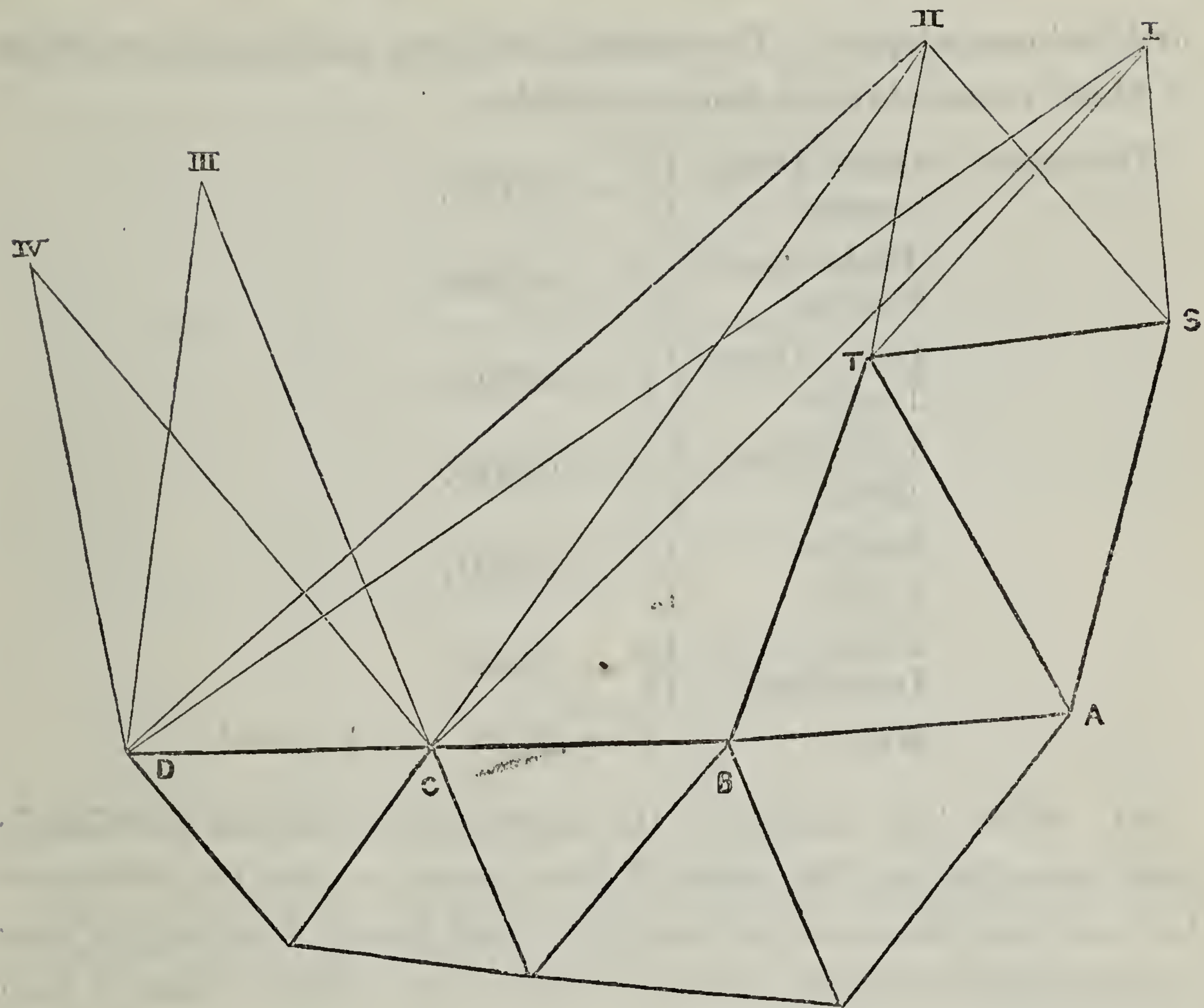
64. *Estimation of Terrestrial Refraction.*—If the contained arc be represented by c, and terrestrial refraction by r, then $\frac{r}{c} = f$ the factor, or "decimals of contained arc." Whereby if f be given, then $r = c.f$ may be computed. From want of a more accurate method of determination, it is usual to adopt that mean value of f, for finding the height of an inaccessible point, which may be forthcoming from the reciprocal observations at visited stations. For instance if A, B, C, D, be points of the last mentioned order, then



in the ordinary course of computation, there will result three values of f at A, as many at C, and two values each at B and D. The mean value of f at each station would therefore be adopted in computing the height of an inaccessible point H. To take a real case (at random). The values of f at Batwya T. S. (1) are $+ 0.011, - 0.017, + 0.065$ and $+ 0.013$. Wherein the greatest difference is no less than .082 of the contained arc. On the other hand, the values of f at hill stations of observation, will always be found accordant within far smaller limits.

65. The conclusion drawn from the foregoing is evidently this. That at plain stations, and when the object observed is placed on an ordinary tower, the value of f determined from any given ray A B, is not necessarily applicable to any other ray A C. Whereas all rays of light at hill stations from terrestrial points appear to be nearly equally refracted. These phenomena are clearly traceable to local causes.

66. But of the two mean values of f, one obtained at a mountain station of observation, and another deduced in the plains, it is evident that the former is more trustworthy, and hence it appeared desirable, that the latter should be obtained in terms of the former.



67. *Process of estimating terrestrial refraction.*—Let A, B, C, D, (vide figure) be plain stations, T and S stations on the Sub-Himalayas, and I. to IV. inaccessible points on the range of perpetual snows. Let the values of f at T and S equal respectively f and f_s. We may deduce from these, two trustworthy values of the heights of I. and II. Calling this mean height of $I = I_m$, and remembering that we have elevation (E) at C of I, as also the contained arc for C I $= (c)$ given, it is clear that the values of f at C, corresponding to I_m may be found. Let this value $= f$. Proceeding in the same manner we shall find $f_c = \frac{f^1 + f^2 + \ldots\ldots + f_n}{n}$

Similarly f_D &c., may be obtained, and with f_c, f_D &c., may be computed III_m, IV_m &c., from which again in turn may be found the values of f for the other plain stations from which III, IV &c, have been observed. By this process the computed values of f are determined nearly in terms of f_t and f_s, errors of observation not being taken into account. It remains to mention how f_s and f_t were obtained.

68. The computations originate from Senchal and Tonglo hill stations, at which stations, the following mean value of f was in the

first instance adopted. The selection has been made to the exclusion of those values obtained from short sides.

Deduction.—	Doom Dangi, Senchal	$f = .07617.$
	Thakoorganj, Senchal	$f = .07636.$
	Doom Dangi, Tonglo	$f = .07915.$
	Thakoorganj, Tonglo	$f = .07849.$
	Senchal, Tonglo	$f = .06201.$
	Tonglo, Darjeeling	$f = .08043.$
	Mean	$f = .0744. = \frac{1}{13.2}$ nearly.

69. With this value of f, the heights from Senchal and Tonglo were computed, and the mean of these values, as also the differences between each value and its mean, were next found. The heights were now corrected, in such wise, that when the heights deduced from Senchal are compared with the mean heights already mentioned, the greatest + and — differences should be numerically equal. The same process being gone through at Tonglo, H. S., there resulted the mean values of f, which have been employed for that station and for Senchal. These values will be found recorded in the heights herein given, and it will also be found, that they have been employed for all heights of the *Sub*-Himalayas observed at Senchal and Tonglo hill stations.

70. It may be useful to remember, that if there be two points A and B observed from O, whose heights respectively are h_a and h_b determined by a certain value of f at O $= f_o$. Also if d_a equal corrected geodetic distance O to A, and $d_b =$ O B. Then if f_o vary, so that h_a (the height of A computed from O) changes by $\pm\, \delta_a$, and h_b by $\pm\, \delta_b$, so will $\pm \frac{\delta_b}{\delta_a} \propto \frac{{d_b}^2}{{d_a}^2}$. Hence should the foregoing method for finding the value of f at plain stations in terms of the observed value at hill stations, be hereafter ever adopted, it will be found advantageous to construct a table of the squares of the distances in miles, for this purpose.

71. The general principle of procedure is now apparent. But as

will be remarked, the process described is only applicable so long as a continuous connection is preserved, between the stations of observation and the points observed. In the observations under consideration, there occurs a blank space between points LII. and LIII whence the method described was no longer applicable beyond the former point. But it fortunately happens that LIII. and succeeding points are observed from hill stations, whereat, as already mentioned, the values of f are liable to but trifling variation. The mean value of f in these cases was deduced in the ordinary way as mentioned at para. 64. The following is an example of this method.

At Jagesar, H. S. the values of

$$(f) \text{ are } \begin{cases} .04485. \\ .04528. \\ .04876. \end{cases}$$

Mean f adopted at Jagesar, H. S. .04630.

72. *Values of f tabulated.*—The values of f employed in these calculations may be tabulated thus.

Height above sea level.	Names of Stations.	f.	Denominator of vulgar fraction.
Feet.			
8610	Senchal, H. S.	.0815	12.2657
319	Doom Dangi, T. S.	.0744	13.4374
7169	Darjeeling, H. S.	.0885	11.2945
6884	Birch Hill, S.	.0864	11.5737
273	Thakoorganj, T. S.	.0775	12.9066
10084	Tonglo, H. S.	.0711	14.0550
251	Banderjoola, T. S.	.0811	12.3317
237	Menai, T. S.	.0753	13.2852
242	Baisi, T. S.	.0743	13.4677
226	Harpoor, T. S.	.0727	13.7637
242	Ladnia, T. S.	.0746	13.4025
263	Janjpati, T. S.	.0731	13.6705
254	Mirzapoor, T. S.	.0736	13.5775
231	Jirol, T. S.	.0735	13.6008
282	Sinereah, T. S.	.0753	13.2797
268	Boolakipoor, T. S.	.0728	13.7429
259	Batwya, T. S.	.0714	14.0093
320	Torharwa, T. S.	.0847	11.8002
357	Morairi, T. S.	.0791	12.6429
353	Soopoor, T. S.	.0813	12.3031
355	Banarsi, T. S.	.0937	10.6681
344	Saonbarsa, T. S.	.0870	11.4928
350	Bharmi, T. S.	.0787	12.7054
329	Poorena, T. S.	.0805	12.4154
358	Ghaos, T. S.	.0875	11.4292

Height above sea level.	Names of Stations.	f.	Denominator of vulgar fraction.
412	Toolsipoor, T. S.	.0763	13.1058
478	Anarkali, T. S.	.0744	13.4432
7732	Jagesar, H. S.	.0463	21.5983
6994	Birond, H. S.	.0652	15.3374
10101	Khankra, H. S.	.0579	17.2652
8526	Soonchalia, H. S.	.0624	16.0256
6946	Ghoongti, H. S.	.0652	15.3374
7079	Ranigarh, H. S.	.0687	14.5624
5675	Mabegarh, H. S.	.0750	13.3333
7371	Ghandial, H. S.	.0698	14.3266
12541	Kiderkanta, H. S.	.0480	20.8377
9946	Nagtiba, H. S.	.0521	19.1902
2970	Dhoiwala, H. S.	.0628	15.9363
7454	Banog, H. S.	.0612	16.3479
3161	Amsot, H. S.	.0565	17.6897
11997	Chur, H. S.	.0530	18.8857

73. *Conclusion deduced from foregoing table.*—Now since

$$\frac{\text{Sin} \angle \text{ incidence}}{\text{Sin} \angle \text{ refraction}} = 1 + m$$

in the mean state of atmosphere and at the level of the sea, and also, since the quantity m varies with the density of the atmosphere, so that when the density of the air is only the n*th* part of what it is at the level of the sea, the refractive power is there only $1 + \frac{m}{n}$, it might have been expected from these tabulated results that in the first instance, $f \propto \frac{1}{\text{height of station of observation}}$. No such law, however, is to be found unless the numerous exceptional cases be excluded to make a rule.

74. Wherefore it appears, that the law of variation in f due to variation in the density of the atmosphere, consequent on variation in height, is completely absorbed and lost sight of in the irregular variations, arising from local causes and also from the unavoidable imperfections of observation to points so ill-defined as the apices of snowy mountains.

75. Finally it is to be noticed that the foregoing method is acknowledged to be imperfect and unsatisfactory, but compared with the ordinary mode of finding f from reciprocal vertical observations,

it is believed that the values herein determined are a nearer approximation to the truth.

76. *Notices certain refinements not appreciable in these operations.*—In concluding the remarks on these computations, it may be interesting to notice certain refinements in calculation which have not been deemed applicable to these operations. For instance, the spheroidal excess and the contained arc might have been computed by more rigorous processes, but that the refinement would have been purely of an arithmetical nature. Again the formula for latitude and longitude has not been employed beyond its fourth term, because the remaining terms are difficult of arithmetical expression and would besides have given no results commensurate with the labour necessary to compute them. Similarly the chord correction is neglected in these heights, amounting as it does in the extreme case of Menai to Mont Everest, or XV, to no more than a foot.

77. There remains to notice one other correction also herein not taken into account, of which it may be remarked, that, under existing circumstances it would partially cancel the chord correction, if both these refinements were introduced. This correction may be stated thus.

78. Ordinarily, in the formula for computing difference of height, it is sufficiently accurate to assume the given arc (or distance) to belong to a circle, whereas in reality, it is a portion of an ellipse. If the correction due to this assumption $= x\,b$, then it can be shown that $x\,b = (\nu a - \text{Cos}\ \lambda_b\ \text{K}) - (\nu_b - \text{Cos}\ \lambda_a\ \text{K})$, wherein K

$$= \left\{ \nu_b \sin \lambda_b - \nu_a \sin \lambda_a + \frac{\text{N}}{\text{M}} [\ (\text{M} + \nu_a\ \text{Cos}\ \lambda_a)\ (\text{M} - \nu_a\ \text{Cos}\ \lambda_a)\ ]^{\frac{1}{2}} - \frac{\text{N}}{\text{M}} [(\text{M} + \nu_a\ \text{Cos}\ \lambda_b)\ (\text{M} - \nu_b\ \text{Cos}\ \lambda_b)\ ]^{\frac{1}{2}} \right\} \text{Cosec}\ \delta\,\lambda.$$

It is sufficient to remark in this place, that in the extreme case of Menai, T. S. to Mont Everest or XV. the correction $x\,b =$ only 0.3 of a foot.

79. *Magnitude of these operations illustrated.*—Lastly it may be interesting to notice, that the area of the largest triangle to points on the Himalaya mountains (No. 297) is about 1706 square miles, its spheroidal excess being 106″. The longest side, Anarkali, T. S. to XXXIX. is equal to 151 miles, and its corresponding contained arc

is 7886″ = about the $\frac{1}{164}$ *th* part of a circle described around our planet. And if the principal and mountain operations of the North East longitudinal series be taken together, they will be found to cover somewhat more than the $\frac{1}{3182}$ portion of the entire earth's surface ; or, taking the land at half the expanse of water, about 1061 such series would cover every portion of the former.

80. *Accuracy discussed.*—And with regard to the accuracy of the mountain results, it is evident that the same estimate cannot equally apply to a peak with a sharp conical apex, and to a mountain whose summit represents a saddle back or an even bluff. Prominent amongst the accurately determined points are XIII. Mont Everest or XV. and XLII. or Dhoulagiri, both in respect to geographical position and height above sea level, but though such points are far more numerous than those which exhibit comparatively large differences between the several values composing their mean results, yet it is suggested that the synopsis of latitudes and longitudes and the paper of heights should be consulted before adopting a point, if necessary for rigorous purposes.

81. *The same estimated.*—It is estimated, that on an average, the points on the Himalaya mountains are correct in latitude to $\frac{1}{4}$ of a second and in longitude to about $\frac{1}{2}$ that quantity. The heights are probably true to 10 feet, but this last estimate must be qualified by the consideration that they are all too low from the deflection due to mountain attraction.

82. *Why mountain attraction was not determined.*—In the original design of these operations, it was intended that the deflections in azimuth and in the meridian due to the attraction of the Himalaya mountains should be estimated along the principal series by suitable celestial observations, but this intention was relinquished owing to the considerable delay it entailed.

84. *Area and cost.*—The area covered by these principal and secondary operations amounts to about 61,815 square miles. But the piecemeal nature of work, the long intervals which frequently occur, and the unavoidable employment of the North East longitudinal series partly on other duties, make it a difficult and unsatisfactory process to attempt finding the cost of these operations. As an approximation, however, it may be stated that this cost does not exceed Rupees 2 per square mile.

Table of characteristic marks, for the snowy peaks of the North East longitudinal series, great Trigonometrical Survey of India, and identification with other authorities.

Final Numeral and Name adopted.	Country.	Identification with other authorities.
I. or Choomlari, ..	Tibet.	
II. or Gipmochi, ..	Bhotan.	
III. or Porohoonri, ..	Tibet & Sikkim.	Named by Dr. Hooker, Donkiah.
IV. or Choomoonko, ..	do.	Named by Dr. Campbell, Chola.
V. or Black rock, ..	do.	Named by Dr. Campbell, Gnaream.
VI. or Narsing, ..	Sikkim.	
VII. or Pandim, ..	do.	
VIII. or Kanchinjinga,	do.	
IX. or Kanchinjinga,..	Nepal & Sikkim.	
X. or Kabroo, ..	do.	
XI. or Jannoo, ..	Nepal.	
XII.	do.	
XIII.	do.	
XIV.	do.	
XV. or Mont Everest.	do.	
XVI.	do.	
XVII.	do.	Colonel Crawford's A.
XVIII.	do.	Colonel Crawford's B.
XIX.	do.	
XX.	do.	Colonel Crawford's C.
XXI.	do.	Colonel Crawford's D.
XXII.	do.	Colonel Crawford's F.
XXIII.	do.	
XXIV.	do.	
XXV. or Dayabang, ..	do.	Colonel Crawford's L. or Dayabang.
XXVI.	do.	
XXVII.	do.	
XXVIII.	do.	
XXIX.	do.	
XXX.	do.	
XXXI.	do.	
XXXII.	do.	
XXXIII.	do.	
XXXIV.	do.	
XXXV.	do.	
XXXVI.	do.	
XXXVII.	do.	
XXXVIII.	do.	
XXXIX.	do.	
XL.	do.	
XLI.	do.	[giri.)
XLII. or Dhoulagiri,..	do.	Capt. Webb's Dhawalagiri, (Dhoula-
XLIII.	do.	
XLIV.	do.	
XLV.	do.	
XLVI.	do.	
XLVII.	do.	
XLVIII.	do.	
XLIX.	do.	

Final Numeral and Name adopted.	Country.	Identification with other authorities.
L.	Nepal.	
LI.	do.	
LII.	do.	
LIII. or Api, ..	do.	Capt. Webb's XXIII. (Api.)
LIV. or Panchachuti,	Kumaon.	Capt. Webb's XIX.
LV.	do.	Capt. Webb's XVIII.
LVI. or Nandakut, ..	do.	Capt. Webb's XV.
LVII.	do.	
LVIII. or Nandadebi,	Kumaon & British Gurhwal.	Capt. Hodgson and Lt. Herbert's A. No. 2; Capt. Webb's XIV.
LIX. . ..		
LX. or (East) Trisool,	British Gurhwal.	Capt. Webb's XIII. (East) Trisool.
LXI.	Kumaon and British Gurhwal.	Capt. Hodgson and Lt. Herbert's P or A. No. 3, Capt. Webb's N.
LXII. or (West) Trisool.	British Gurhwal.	Capt. Hodgson and Lt. Herbert's A. No. 1; Capt. Webb's XII. or West Trisool.
LXIII.	do.	
LXIV. or Nandakna, .	do.	Capt. Webb's XI. (Nandakna.)
LXV. or Nandakna, ..		
LXVI.	do.	Capt. Webb's K.
LXVII. or Kamet or Ibi Gamin, ..	Tibet and British Gurhwal.	Capt. R. Strachey's Kamet, named by* Messrs. Schlagintweit Ibi Gamin.
LXVIII. or Nilakanta,	British Gurhwal.	Capt. Webb's IX. (Nilakanta.)
LXIX. or Badrinath, ..	do.	Capt. Hodgson and Lt. Herbert's B. Middle peak Badrinath, Capt. Webb's VIII.
LXX.	do.	Capt. Webb's VI.
LXXI.	do.	Capt. Webb's G.
LXXII. or Kedarnath,	Gurhwal and British Gurhwal.	Capt. Hodgson and Lt. Herbert's D. or Kedarnath, Capt. Webb's III. Mr. Keelan's *a*.
LXXIII.	Gurhwal.	
LXXIV. or Tharlasagar, ...		Capt. Hodgson and Lt. Herbert's M. or Mont Moira, Capt. Webb's 1. Mr. Keelan's *e*.
LXXV. or Jaouli, ..	do.	Capt. Hodgson and Lt. Herbert's C. or Jaouli, Mr. Keelan's *i*.
LXXVI. or Bus Peak or Srikanta, ..	do.	Capt. Hodgson and Lt. Herbert's G. or Srikanta. Mr. Keelan's *d*. Mr. Mulheran's I. or Srikanta. Mr. Dyer's Srikanta.
LXXVII. or Banderpoonch, ...	do.	Capt. Hodgson and Lt. Herbert's Great E. or Banderpoonch. Mr. Keelan's *a*. Mr. Dyer's *l*.
LXXVIII.	do.	Capt. Hodgson and Lt. Herbert's Low E.
LXXIX. or Sargoroen,	do.	Capt. Hodgson and Lt. Herbert's H. Left peak.

* Capt. Strachey's Kamet, Lat. 30° 55′ 20″ Long. 79° 37′ 55″ Heigt. 25500 ft.
LXVII.............. „ 30 55 13 „ 79 38 4 „ 25373
(Vide map of Kumaon and British Gurhwal.)

NORTH-EAST LONGITUDINAL SERIES.

General Alphabetical List of Latitudes, Longitudes and Heights.

No.	Names of Places.	Latitudes.	Longitudes.	Heights above sea level.	District.	Remarks.
		° ′ ″	° ′ ″	feet.		
1309(1)	Darjeeling Church, N. W. spire, ..	27 2 52	88 18 36	..	British Sikkim.	
1310(1)	Darjeeling, Campbell's (Dr.) centre chimney,	27 2 23	88 18 32	..	Do.	
1209	Darjeeling, H. S., ...	27 2 49.65	88 18 40.76	7169	Darjeeling, British Sikkim.	
181	Kishanganj Rajah's Noubatkhana, ..	26 6 18	87 59 22			
650	Debi Patan Temple, ...	27 32 10	82 26 15			
841	Bhinga Fort, ...	27 41 49	81 58 52			
873	Akowna Temple, Golden Kalas in the centre of city, ...	27 31 56	82 0 45			
1193(1)	Shahjehanpoor Hakeem Maindees Koti, large 2-storied house, centre of stair-case, ..	27 53 54	79 58 12			
1194(1)	Shahjehanpoor, Magistrate's and Collector's Office, most northern skylight, ..	27 53 8	79 57 40			
1326(1)	Landour Hospital, ...	30 27 19	78 8 50	7383	Landour Hills, N. of Dehra.	
1327	Landour Laltiba Hill Station, ...	30 27 30	78 8 32	7485	Do.	
1328(1)	Landour Protestant Church, ...	30 27 40	78 8 16	7308	Do.	
1221(1)	Masuri Camel's Back H. S., ...	30 27 36.41	78 6 58.71	7050	Do.	
1319(1)	Masuri Library, top of S. E. corner, ..	30 27 35	78 6 23	6620	Do.	
1317(1)	Masuri Himalaya Club top of westernmost chimney, ...	30 27 14	78 7 37	6789	Do.	
1220	Dehra Dhoon Observatory Station, ..	30 19 57.12	78 6 2.20	2310	Dehra Dhoon.	

NORTH-EAST LONGITUDINAL SERIES—(Continued.)

Points on the great Himalaya Ranges.

No.	Names of Places.	Latitudes.			Longitudes.			Heights above sea level.	District.	Remarks.
		°	′	″	°	′	″	feet.		
1223	I. or Choomalari, ...	27	49	42	89	18	43	23944	Tibet.	
1224	II. or Gipmochi, ...	27	16	27	88	56	37	14518	Bhotan.	
1225	III. or Powhoonri, ...	27	56	57	88	53	5	23186	Tibet and Sikkim.	
1226	IV. or Choomoonko, ...	27	27	32	88	49	38	17325	Do.	
1227	V. or Black Rock, ...	27	34	11	88	48	39	17572	Do.	
1228	VI. or Narsing, ...	27	30	40	88	19	28	19146	Sikkim.	
1229	VII. or Pandim, ...	27	34	38	88	15	35	22017	Do.	
1230	VIII. or Kanchinjinga, ...	27	41	30	88	11	50	27815	Do.	
1231	IX. or ditto, ...	27	42	9	88	11	26	28156	Nepal and Sikkim.	
1232	X. or Kabroo, ...	27	36	30	88	9	15	24015	Do.	
1233	XI. or Jannoo, ...	27	40	56	88	5	13	25304	Nepal.	
1235	XIII.	27	53	22	87	7	54	27799	Do.	
1236	XIV.	27	46	31	87	1	21	24020	Do.	
1237	XV. or Mont Everest, ...	27	59	17	86	58	6	29002	Do.	
1238	XVI.	27	45	20	86	51	56	22215	Do.	
1239	XVII.	27	45	16	86	36	57	22826	Do.	
1240	XVIII.	27	52	51	86	31	57	21987	Do.	
1241	XIX.	27	58	18	86	28	32	23570	Do.	
1242	XX.	27	57	52	86	22	42	23447	Do.	
1243	XXI.	27	57	29	86	9	8	19560	Do.	
1244	XXII.	28	7	41	85	54	42	21853	Do.	
1245	XXIII.	28	21	8	85	49	21	26305	Do.	
1246	XXIV.	28	10	25	85	49	17	22891	Do.	
1247	XXV. or Dayabang, ...	28	15	22	85	33	35	23762	Do.	

1248	XXVI.	28	23	30	85	10	12	24313	Do.
1249	XXVII.	28	20	43	85	7	24	23313	Do.
1250	XXVIII.	28	26	3	84	41	0	25818	Do.
1251	XXIX.	28	30	12	84	36	34	25729	Do.
1252	XXX.	28	33	0	84	36	9	26680	Do.
1255	XXXIII.	28	29	23	84	13	56	22947	Do.
1256	XXXIV.	28	32	5	84	9	52	26069	Do.
1257	XXXV.	28	32	11	84	7	32	24718	Do.
1258	XXXVI.	28	35	3	84	1	57	24780	Do.
1259	XXXVII.	28	29	42	83	59	22	22964	Do.
1260	XXXVIII.	28	29	54	83	59	20	22986	Do.
1261	XXXIX.	28	35	44	83	51	46	26522	Do.
1262	XL.	28	31	5	83	50	55	23641	Do.
1263	XLI.	28	39	17	83	46	22	22471	Do.
1264	XLII. or Dhoulagiri,	28	41	48	83	32	9	26826	Do.
1265	XLIII.	28	45	45	83	25	52	25456	Do.
1266	XLIV.	28	45	13	83	25	12	25299	Do.
1267	XLV.	28	44	2	83	24	18	24912	Do.
1268	XLVI.	28	44	7	83	21	20	25095	Do.
1269	XLVII.	28	40	26	83	19	6	23565	Do.
1270	XLVIII.	28	43	54	83	15	9	24181	Do.
1271	XLIX.	28	44	52	83	11	18	23779	Do.
1272	L.	28	44	36	83	9	29	21727	Do.
1273	LI.	28	45	59	83	8	27	21472	Do.
1274	LII.	28	49	39	82	39	33	19415	Do.
1276	LIV. or Panchachuli,	30	12	51	80	28	9	22673	Kumaon.
1277	LV.	30	15	12	80	25	5	21471	Do.
1278	LVI. or Nandakut,	30	16	51	80	6	39	22538	Do.
1279	LVII.	30	21	58	80	2	21	24417	Do.
1280	LVIII. or Nanda Debi,	30	22	31	80	0	50	25661	Kumaon and British Gurhwal.
1281	LIX.	30	22	35	80	0	46	25587	Do.
1282	LX. or East Trisool,	30	16	14	79	54	51	22342	British Gurhwal.
1283	LXI.	30	30	56	79	54	31	23092	Kumaon and British Gurhwal.
1284	LXII. or West Trisool,	30	18	43	79	49	7	23382	British Gurhwal.

NORTH-EAST LONGITUDINAL SERIES—(*Concluded.*)

No.	Names of Places.	Latitudes.			Longitudes.			Heights above sea level.	District.	Remarks.
		°	′	″	°	′	″	feet.		
1285	LXIII.	30	22	9	79	45	40	19916	British Gurhwal.	
1286	LXIV. or Nandakna, ...	30	20	56	79	45	36	20722	Do.	
1287	LXV. or ditto, ...	30	20	57	79	45	35	20773	Do.	
1288	LXVI.	30	41	6	79	44	53	22093	Do.	
1289	LXVII. or Kamet or Ibi Gamin, ..	30	55	13	79	38	4	25373	Tibet and British Gurhwal.	
1290	LXVIII. or Nilakanta, ...	30	43	52	79	26	56	21661	British Gurhwal.	
1291	LXIX. or Badrinath, ...	30	44	16	79	19	20	23210	Do.	
1292	LXX.	30	43	22	79	17	52	22511	Do.	
1293	LXXI.	30	46	44	79	16	58	22347	Do.	
1294	LXXII. or Kedernath, ...	30	47	53	79	6	34	22790	Gurhwal & British Gurhwal.	
1295	LXXIII.	30	51	40	79	2	14	22582	Gurhwal.	
1296	LXXIV. or Tharlasagar, ...	30	51	41	79	2	13	22628	Do.	
1297	LXXV. or Jaonli, ...	30	51	18	78	53	53	21672	Do.	
1298	LXXVI. or Bus Peak or Srikanta, ..	30	57	25	78	50	50	20149	Do.	
1299	LXXVII. or Banderpoonch, ...	31	0	12	78	35	45	20758	Do.	
1300	LXXVIII.	31	0	25	78	34	6	20038	Do.	
1301	LXXIX. or Sargoroen, .. .	31	6	8	78	32	32	20405	Do.	

The Latitude depends on the value of that element adopted for Kalianpoor Station = 24° 7′ 11″.262.

The Longitude is referrible to the old value for the Madras Observatory = 80° 17′ 21″ to which a correction of — 3′ 25″.5 is applicable to reduce to the value adopted by the Admiralty and Royal Astronomical Society or — 3′ 1″.8 to reduce to the result of Taylor's observations up to 1845.

The Heights originate from the mean sea level, observed in Kydd's Dock-yard, Calcutta.